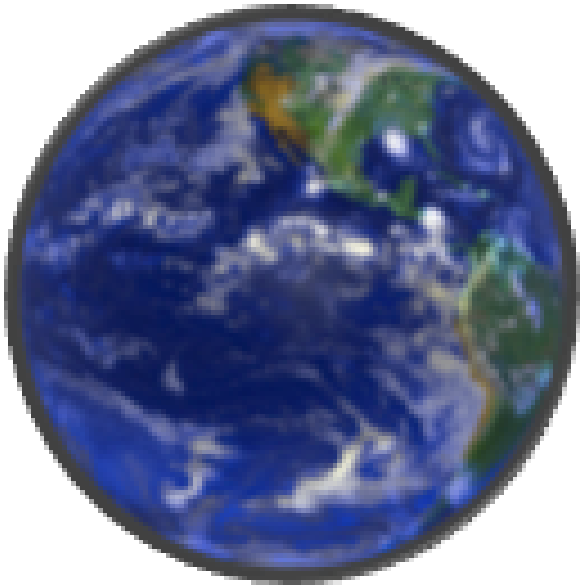
Climate Change:
Science, Impacts, Technologies and policy

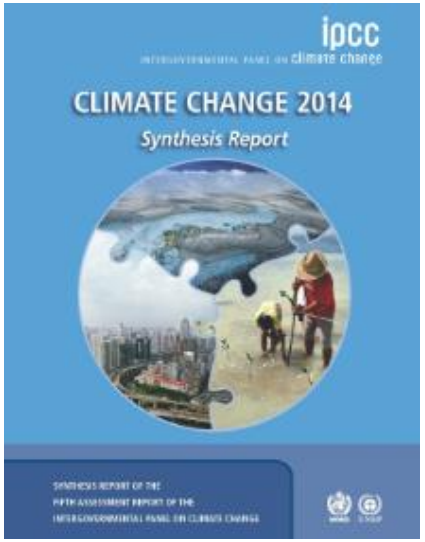
Seminar 1: Synthesis Report: Key Concepts and Findings



Drs. Marilyn Brown and Emanuele Massetti
School of Public Policy
Georgia Institute of Technology

Agenda

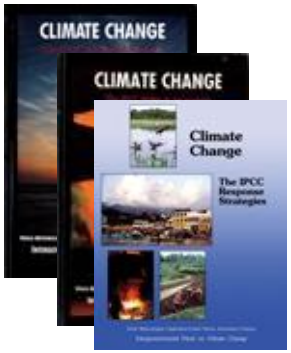
- Introduction to the Intergovernmental Panel on Climate Change (IPCC) and the seminar series
  - Marilyn Brown
- Key concepts and findings from the Synthesis Report
  - Emanuele Massetti
  - Marilyn Brown
- Next Steps
  - Emanuele Massetti

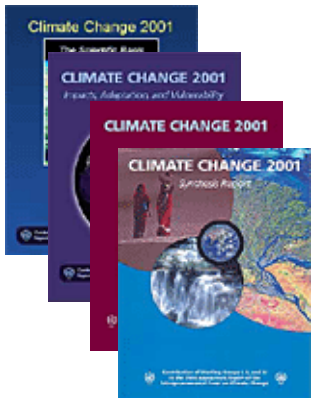


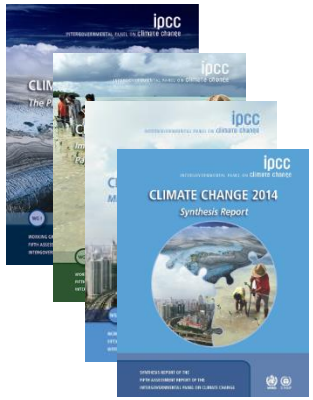
IPCC, 2014, *Climate Change 2014: Synthesis Report*, R.K. Pachauri and L.A. Meyer (eds.). IPCC, Geneva, Switzerland, 151 pp.

Introduction to the IPCC

- Provide policymakers with regular assessments of
  - the scientific basis of climate change,
  - its impacts and future risks, and
  - options for adaptation and mitigation
- Inform negotiations at UN Framework Convention on Climate Change (UNFCCC)



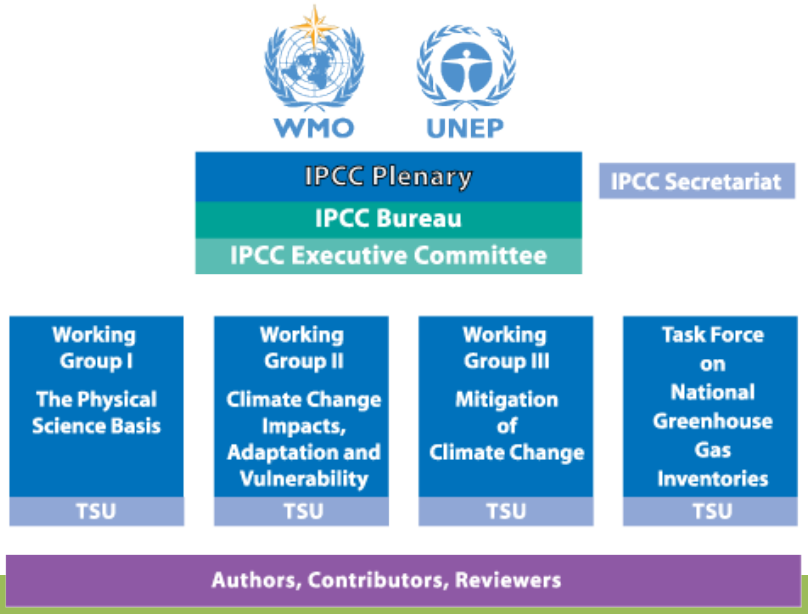




Website for IPCC reports: http://www.ipcc.ch/report/ar5/

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

- Established by World Meteorological Organization (WMO) and UN Environment Program (UNEP) in 1988
- Mandate from December '88 UN General Assembly resolution
- "The IPCC is a scientific body under the auspices of the United Nations (UN)."
(http://www.ipcc.ch/organization/organization.shtml#.Uucv-NIo4-U)
- "The IPCC is an intergovernmental body. It is open to all member countries of the United Nations (UN) and WMO."
(http://www.ipcc.ch/organization/organization.shtml#.Uucv-NIo4-U)



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2007 — Fourth Assessment Report (AR4)
Nobel Peace Prize (shared with Al Gore)
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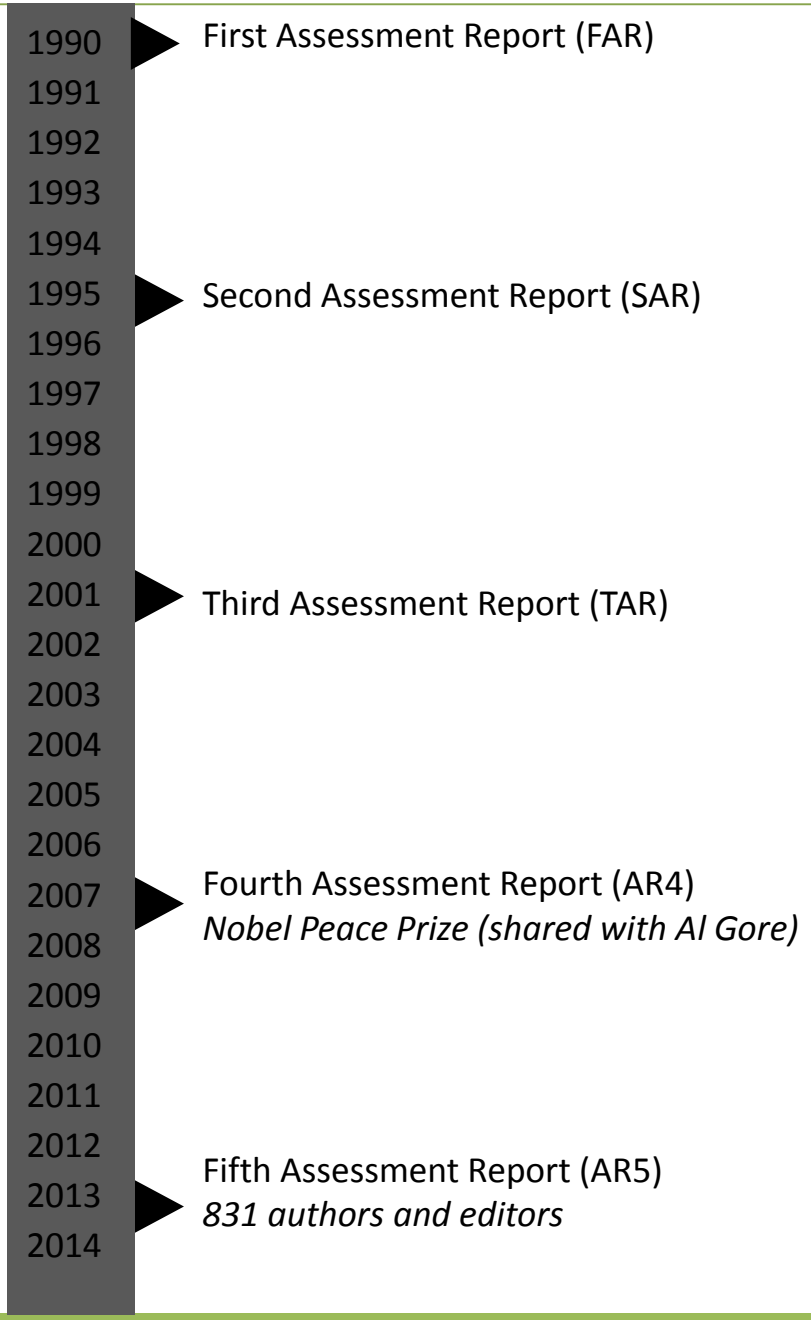
2013 — Fifth Assessment Report (AR5)
831 authors and editors
2014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Nobel Peace Prize (shared with Al Gore)
Fifth Assessment Report (AR5)
831 authors and editors

1990 First Assessment Report (FAR)	"The *unequivocal detection* of the enhanced greenhouse effect from observations is **not likely** for a decade or more."
1991	
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1993	
1994	"The **balance of evidence** suggests a *discernable human influence* on global climate."
1995 Second Assessment Report (SAR)	
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2000	"There is **new and stronger evidence** that most of the warming observed over the last 50 years is attributable to *human activities*."
2001 Third Assessment Report (TAR)	
2002	
2003	
2004	
2005	"Most of the observed increase is global average temperature since the mid-20th century is **very likely** due to the observed increase in *anthropogenic greenhouse gas concentrations*."
2006	
2007 Fourth Assessment Report (AR4) *Nobel Peace Prize (shared with Al Gore)*	
2008	
2009	
2010	"It is **extremely likely** that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the *anthropogenic increase in greenhouse gas concentrations* and other anthropogenic forcings together."
2011	
2012	
2013 Fifth Assessment Report (AR5) *831 authors and editors*	
2014	

Likelihood

Table 1. Likelihood Scale	
Term*	**Likelihood of the Outcome**
Virtually certain	99-100% probability
Extremely likely	95-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33-66% probability
Unlikely	0-33% probability
Very Unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

Anthropogenic Forcings Needed to Match Climate Models to Observations

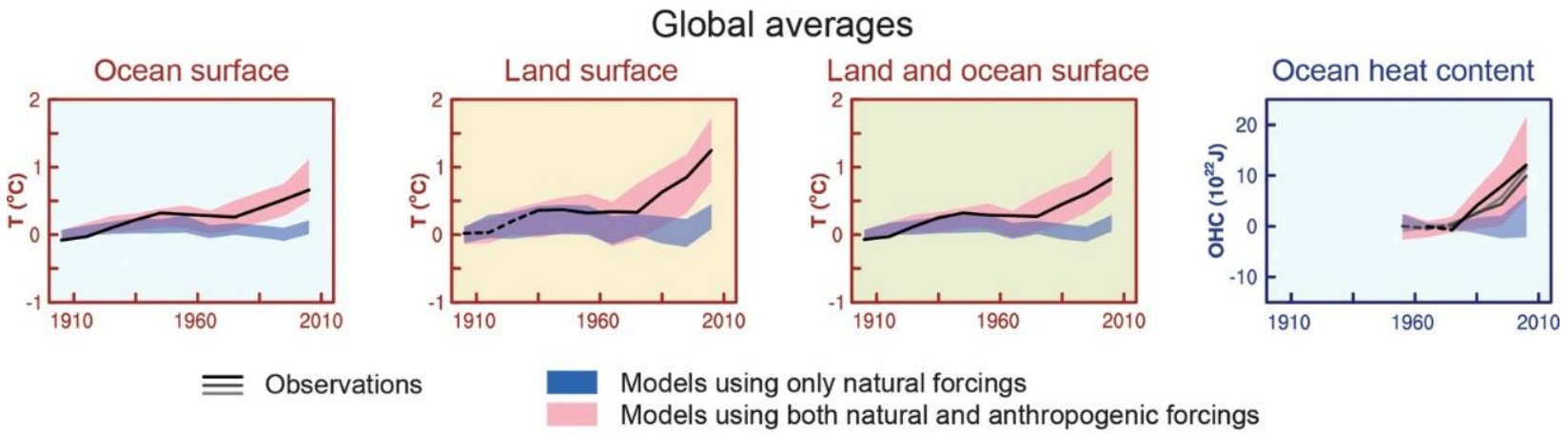


Figure 1.10

IPCC Representation

- Over 800+ authors in 2014
  - 36% from developing or transitioning economies
  - 21% female
  - 63% new members (not previously involved in IPCC report)

- 80+ countries
  - 34% Europe
  - 28% North America
  - 16% Asia
  - 8% Africa
  - 7% South West Pacific
  - 6% South America

- Authorship open to member nations of WMO & UN
  - Overseen by 195-member Panel
  - Selected by Bureau (which is elected by Panel)

- Selected from applicants based on
  - Expertise
  - Scientific, technical and socio-economic perspectives
  - Regional representation

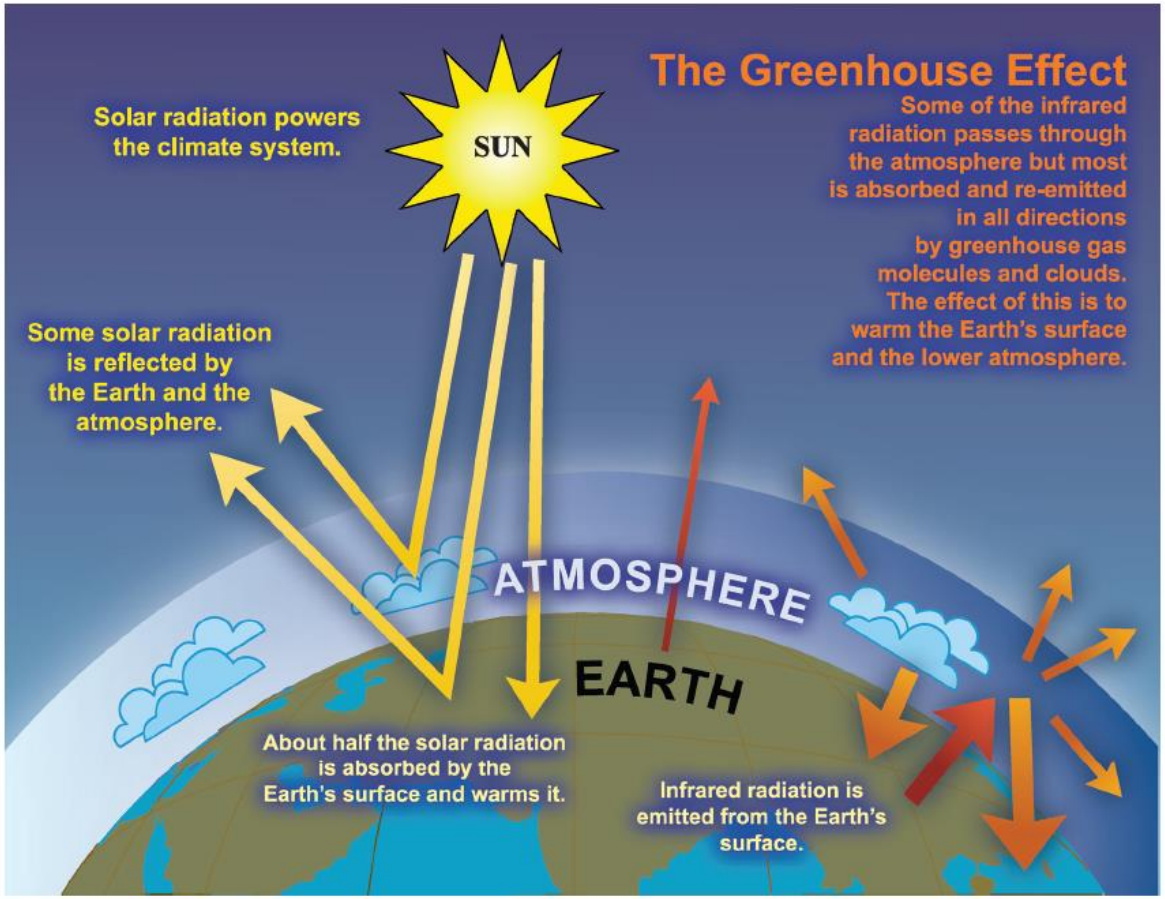
IPCC Report Process

- Material
  - Peer-reviewed journal publications
  - Government, industry and research organization reports
  - Experience and practice in mitigation & adaptation
- Authors
  - Coordinating Lead Authors: Coordinate writing by the working group
  - Lead Authors: Write significant portions of the report
  - Contributing Authors: Provide topic-specific expertise & writing
- Reviewers
  - Review Editors – Ensure all comments are addressed
  - Expert Reviewers – Any self-reported expert or organization representative
- Approval
  - By member nation vote

Synthesis Report: Climate Change

- Selected findings
  - Global temperature and global GHG concentrations
  - Dissecting global warming
  - Observed climate change
  - Projected climate change
- Some evolving IPCC cross-cutting concepts:
  - Treatment of uncertainty
  - Scenarios of emissions

The Greenhouse Effect



FAQ 1.3, Figure 1. *An idealised model of the natural greenhouse effect. See text for explanation.*

Source: IPCC, Working Group I, 2007

Evidence, Agreement, Confidence

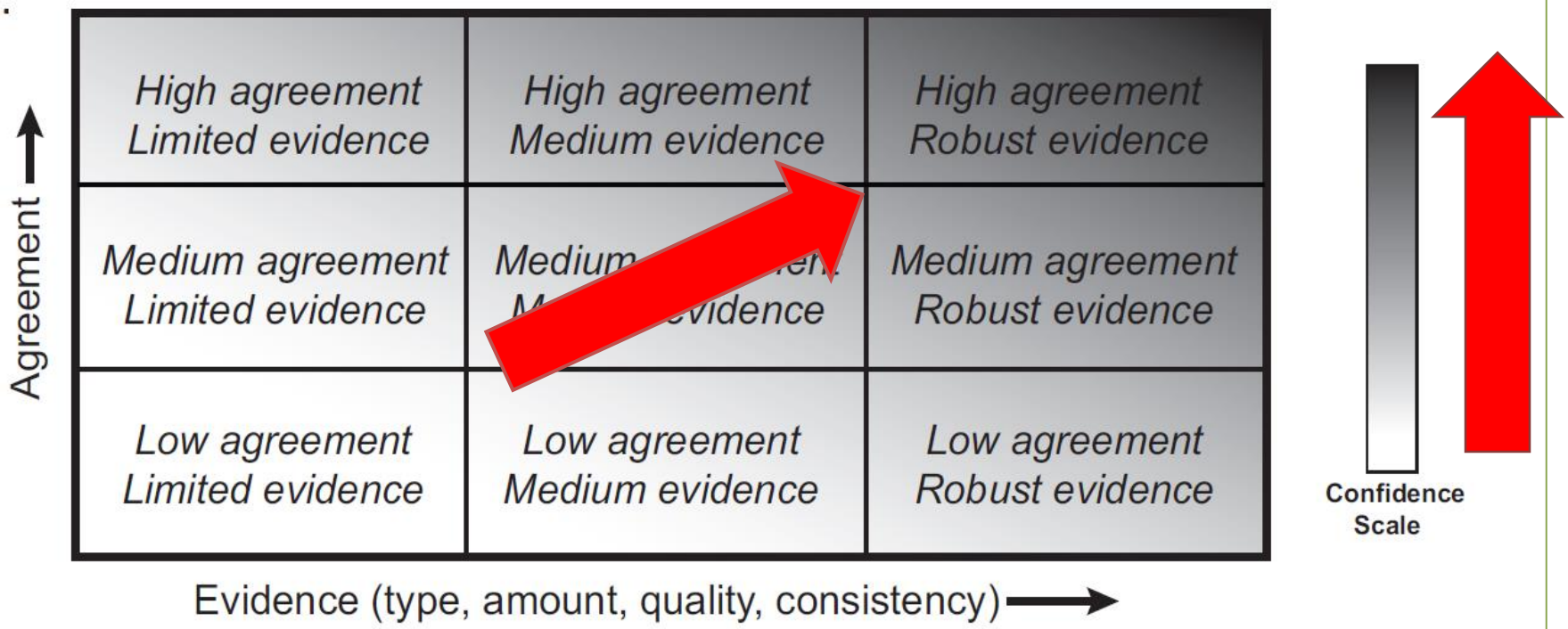
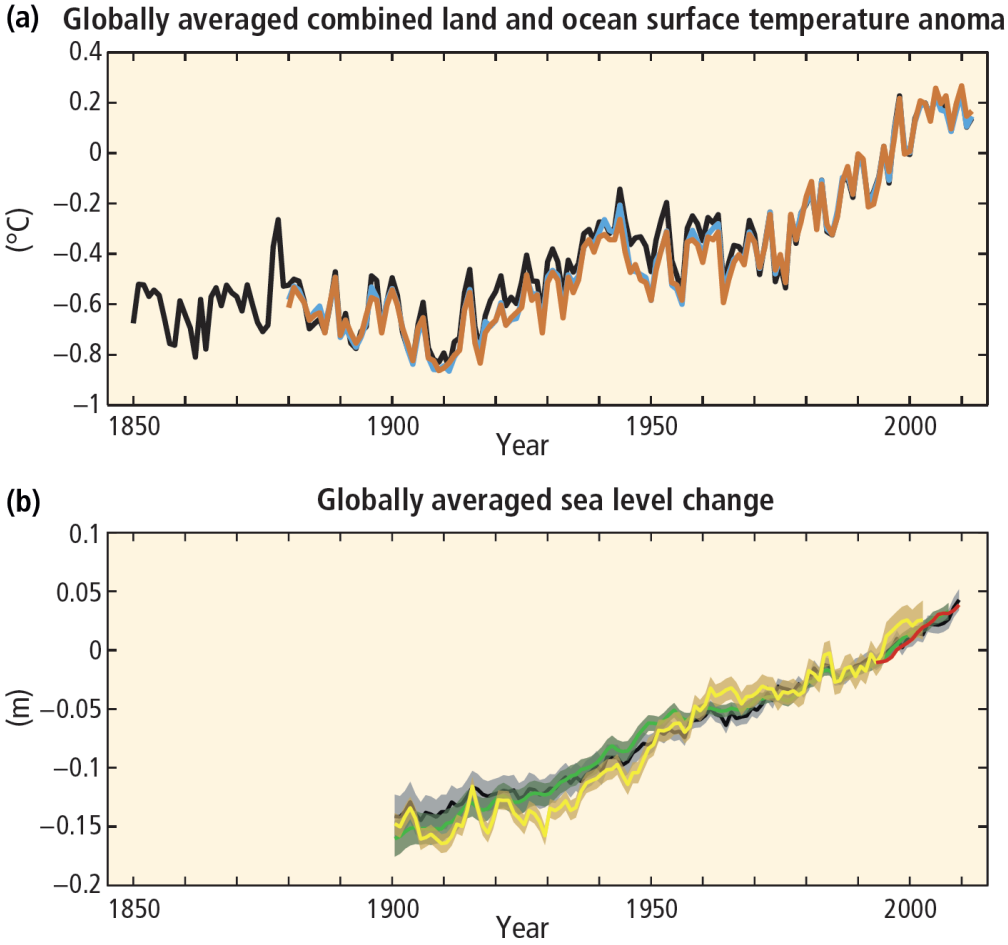


Figure 1: A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence.

Source: Mastrandrea et al. (2010).

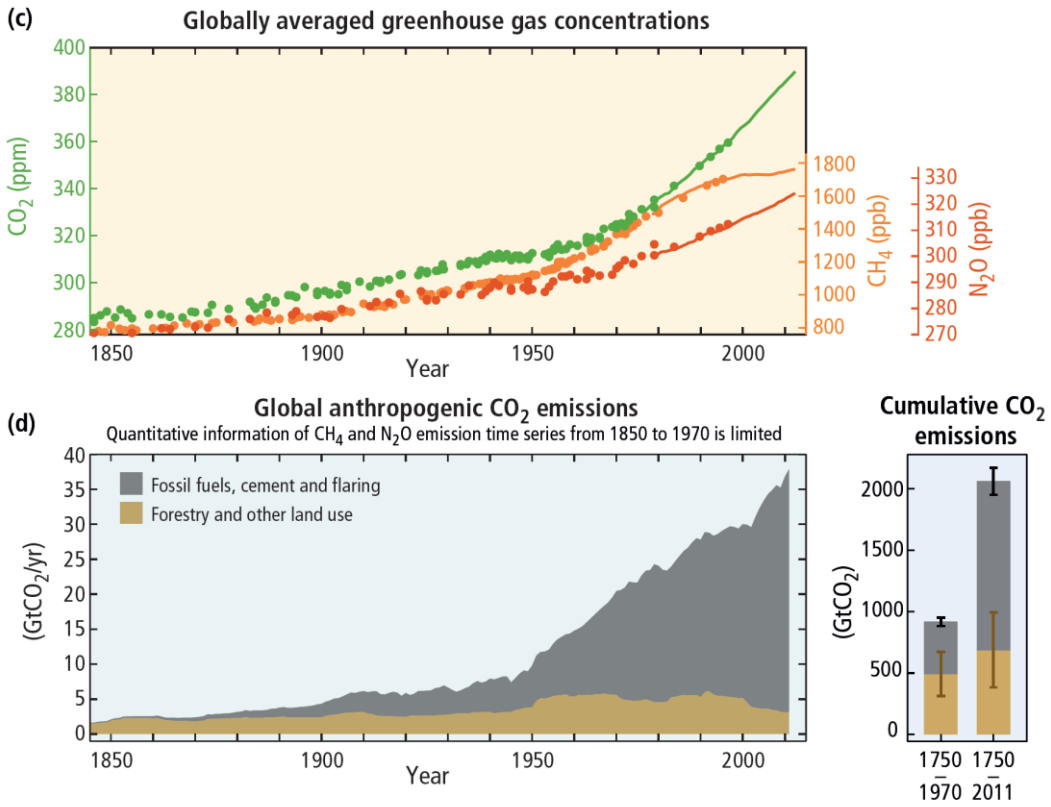
Observed Trends



- Warming unequivocal
- +0.85˚ C since 1880
- 1983-2012 *likely* the warmest period since 1400
- Ocean warming dominates
- Sea-level rose by 0.19 [0.17 to 0.21] m

Figure SPM1.

Causes of Warming



- Warming *extremely likely* due to anthropogenic drivers
- Concentration of GHG unprecedented over 800,000 years

Source: IPCC AR5 Synthesis Report Figure SPM1.

Dissecting Global Warming

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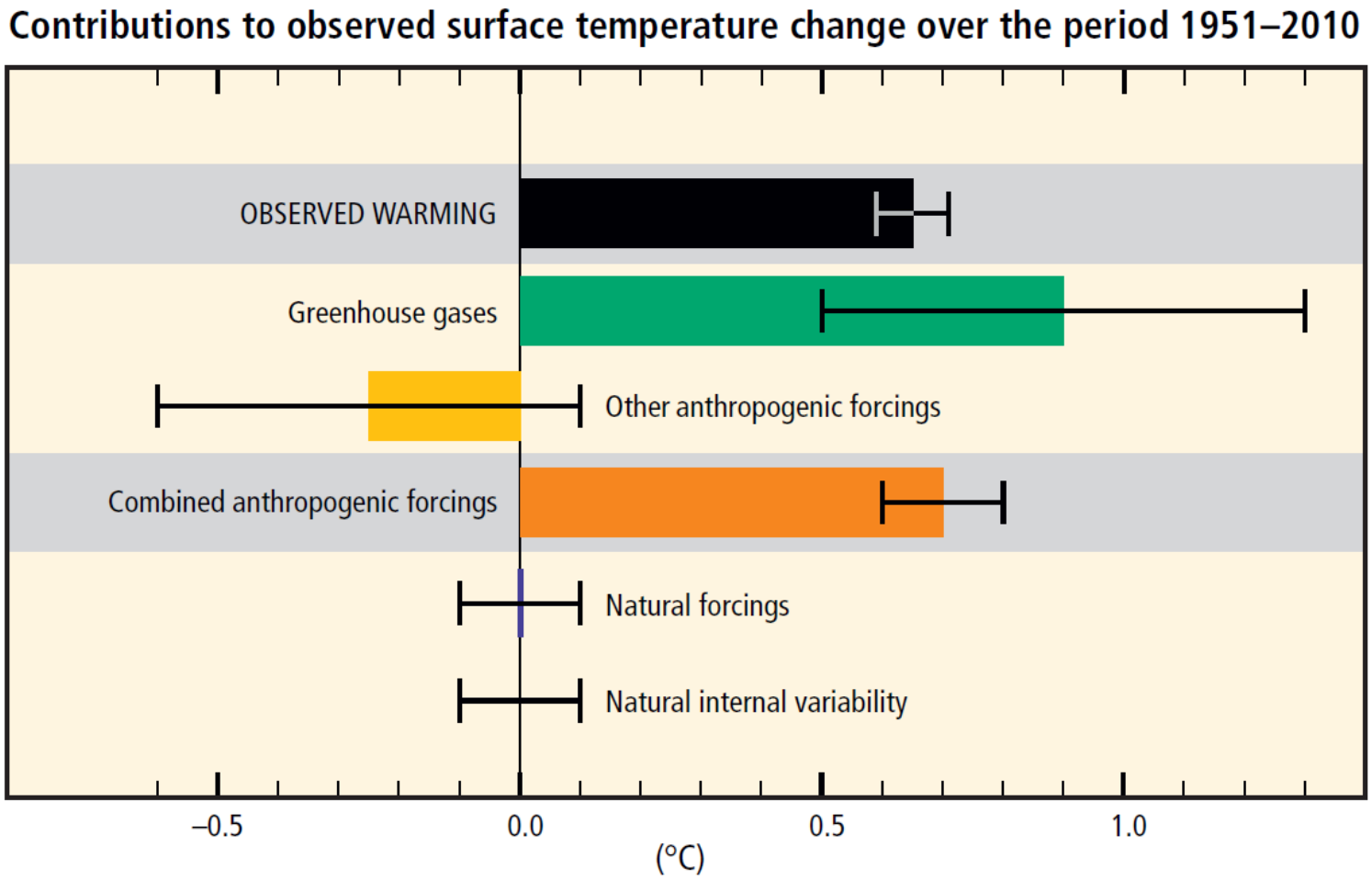


Figure SPM3.

Greenhouse Gas Emissions

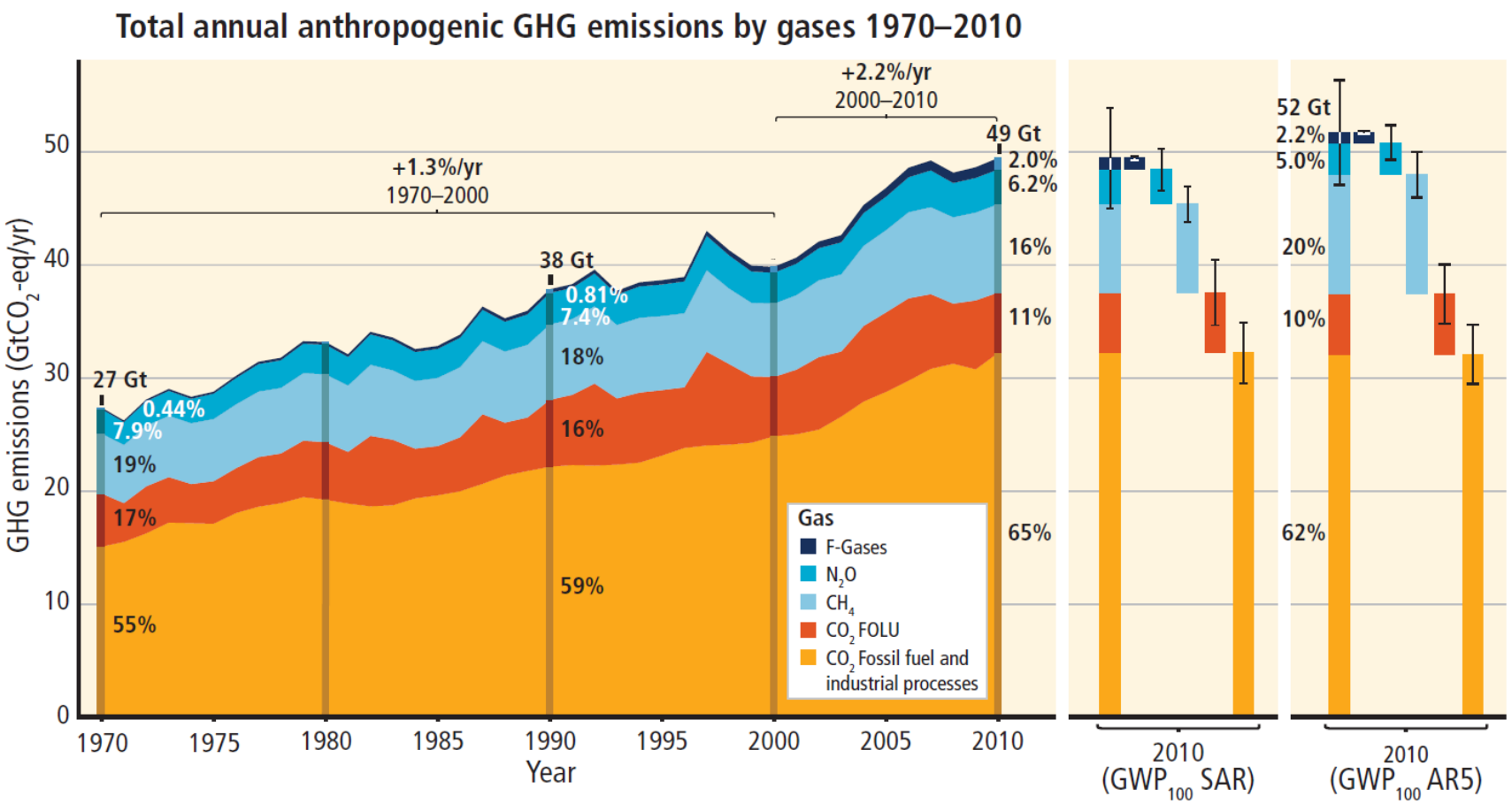


Figure SPM2 .

Observed Impacts

- Extremely likely
  - Increase of global temperature from 1951 to 2010
- Very likely
  - Reduction of Arctic sea-ice sheet since 1979
  - Increase of global upper ocean heat content
  - Sea-level rise
- Likely
  - Increase of continental temperature
  - Global water cycle from 1960
  - Retreat of glaciers from 1960s

Observed Impacts – Extreme Events

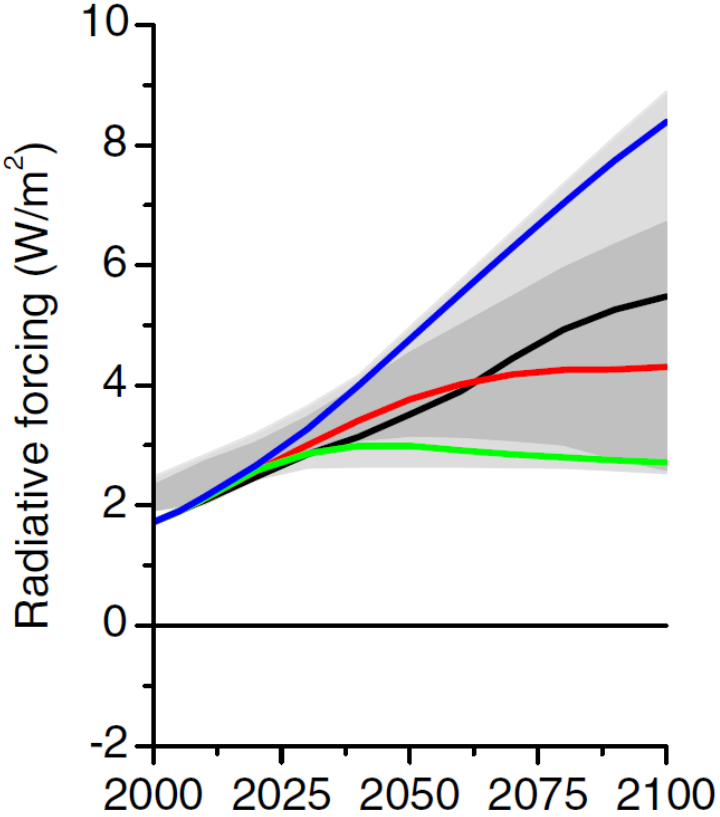
- Very likely:
  - Number of cold days and nights has decreased and the number of warm days and nights has increased
- Likely:
  - Heavy precipitations events increased in North American and Europe
  - Extreme sea levels have increased since 1970
- Medium evidence:
  - Increased heat-related human mortality and decreased cold-related human mortality in some regions is due to observed warming

Observed Impacts – Extreme Events

- Very high confidence
  - Large vulnerabilities from climate-related extremes
  - Direct and insured losses from weather-related disasters have increased substantially in recent decades

- Low confidence:
  - Anthropogenic climate change has affected frequency and magnitude of fluvial floods on a global scale
  - Existence of any trend in droughts at global level
  - Existence of any trend in tropical cyclone activity
  - Attribution of observed droughts and tropical cyclones

The RCPs



- Four GHG concentration pathways
- RCPs are defined by levels of radiative forcing
- Main focus is on emissions, not socio-economic drivers

Notes: Trends in radiative forcing. […] Grey area indicates the 98th and 90th percentiles (light/dark grey) of the literature. Forcing is relative to pre-industrial values and does not include land use (albedo), dust, or nitrate aerosol forcing. Source: van Vuuren et al. (2011), Figure 10.

Linking RCPs and the Literature on Emissions Scenarios

- RCP 8.5 is a pessimistic scenario
- Most Baseline (BaU) scenarios in the literature between RCP8.5 and RCP6.0

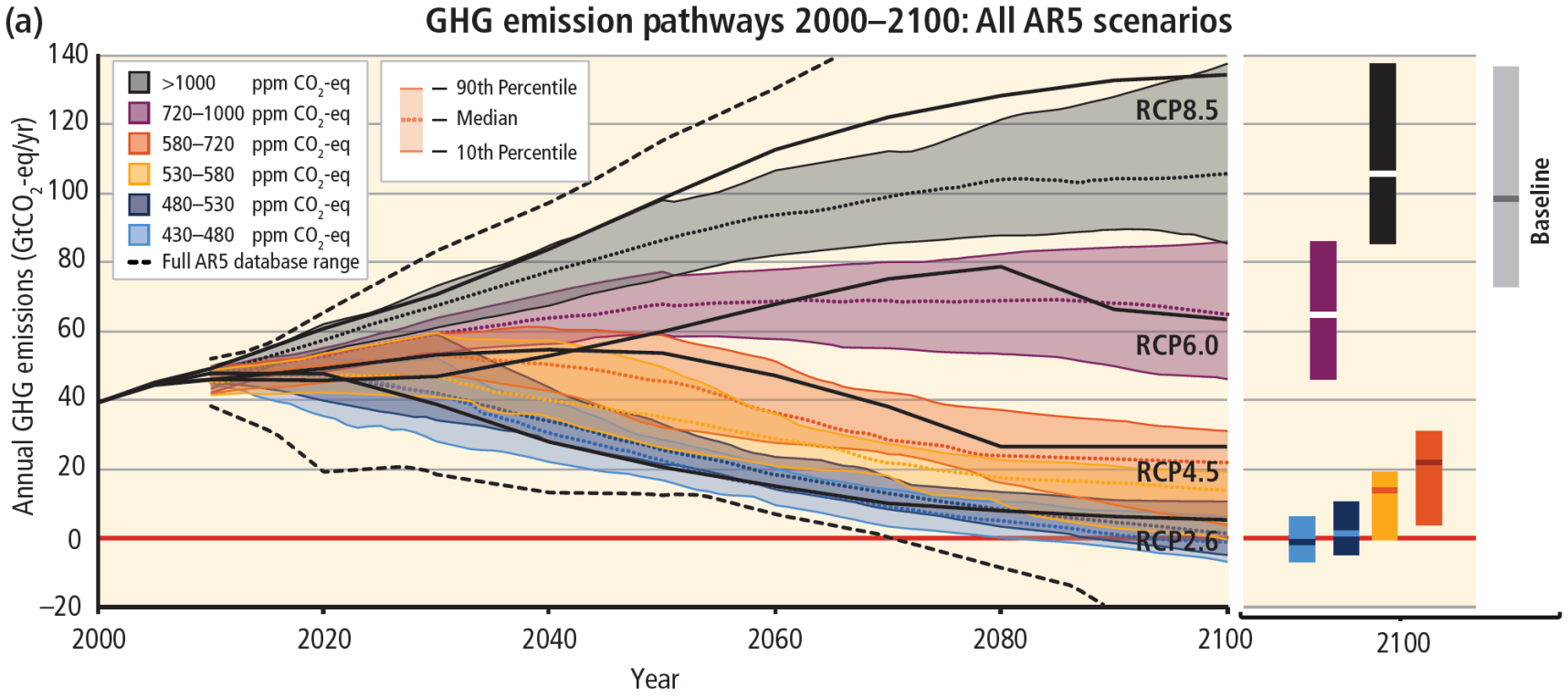


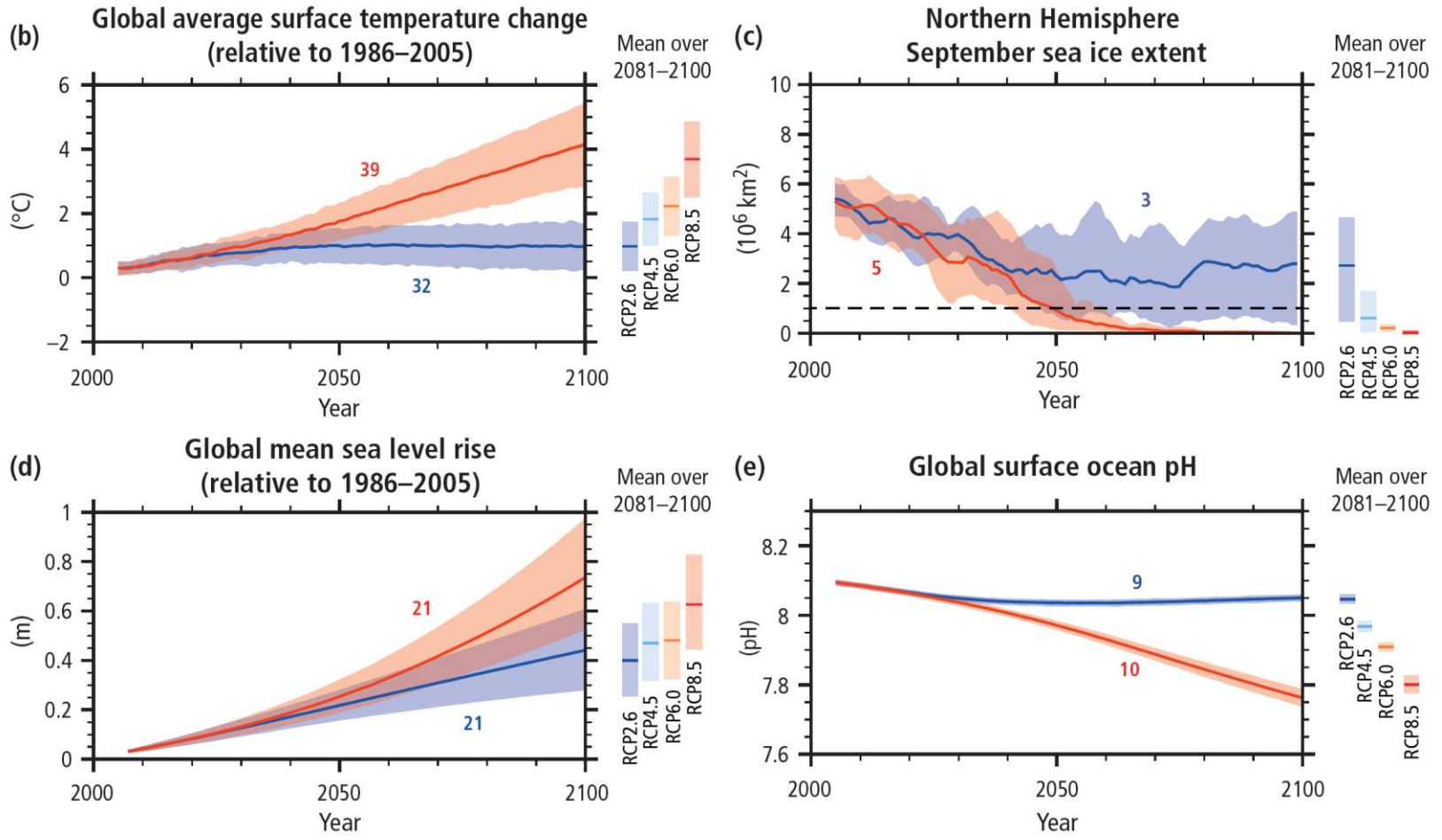
Figure SPM.11

From RCPs to Climate Change Scenarios

- General Circulation Models
  - Weather forecasts up to 2100 and beyond
  - Internal noise due to chaotic dynamics
  - Signal-to-noise ratio

- Fundamental uncertainty
- Ensemble means provide more robust information
- Ensemble means, not expected values

Temperature and Sea-level Rise Scenarios



Source: IPCC AR5 Synthesis Report Figure 2.1. (b) Projections [relative to 1986–2005] are shown for the multi-model mean (solid lines) and the 5 to 95% range across the distribution of individual models (shading).). (c) Change in Northern Hemisphere September sea-ice extent (5 year running mean). The dashed line represents nearly ice-free conditions […]. […] The number of CMIP5 models used to calculate the multi-model mean is indicated. The mean and associated uncertainties averaged over the 2081–2100 period are given for all RCP scenarios as coloured vertical bars on the right hand side of panels (b) to (e).

Temperature and sea level (wrt 1986-2005)

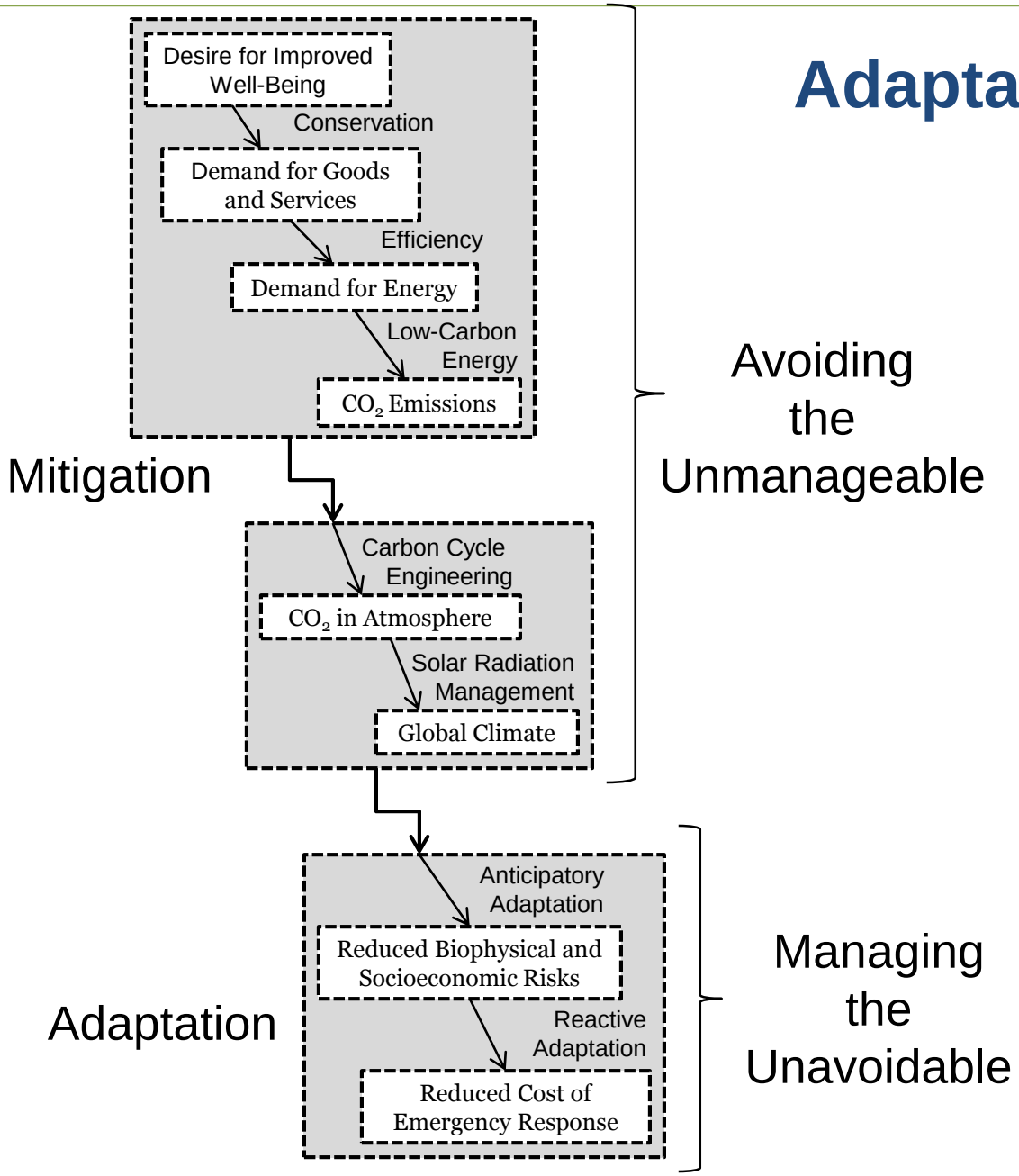
		2046–2065		2081–2100	
	Scenario	**Mean**	***Likely* range** [c]	**Mean**	***Likely* range** [c]
Global Mean Surface Temperature Change (°C) [a]	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8
	Scenario	**Mean**	***Likely* range** [d]	**Mean**	***Likely* range** [d]
Global Mean Sea Level Rise (m) [b]	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

Source: IPCC AR5 Synthesis Report Table 2.1. Projected change in global mean surface temperature and global mean sea level rise for the mid- and late 21st century, relative to the 1986–2005 period.

Synthesis Report: Adaptation & Mitigation

- Some evolving cross-cutting concepts:
  - Complementarity of adaptation and mitigation
  - Economic assessment of climate change risk
  - Constraints and barriers to policy
  - Metrics

Adaptation & Mitigation: Complementary Strategies



SPM: "no single option is sufficient by itself."

Source: Brown, Marilyn A. 2011. *Climate Change and Global Energy Security* (MIT Press).

Emissions for Baseline & Mitigation Scenarios

Mitigation options are available in every sector.

Figure SPM.14

Widespread Impacts Attributable to Climate Change

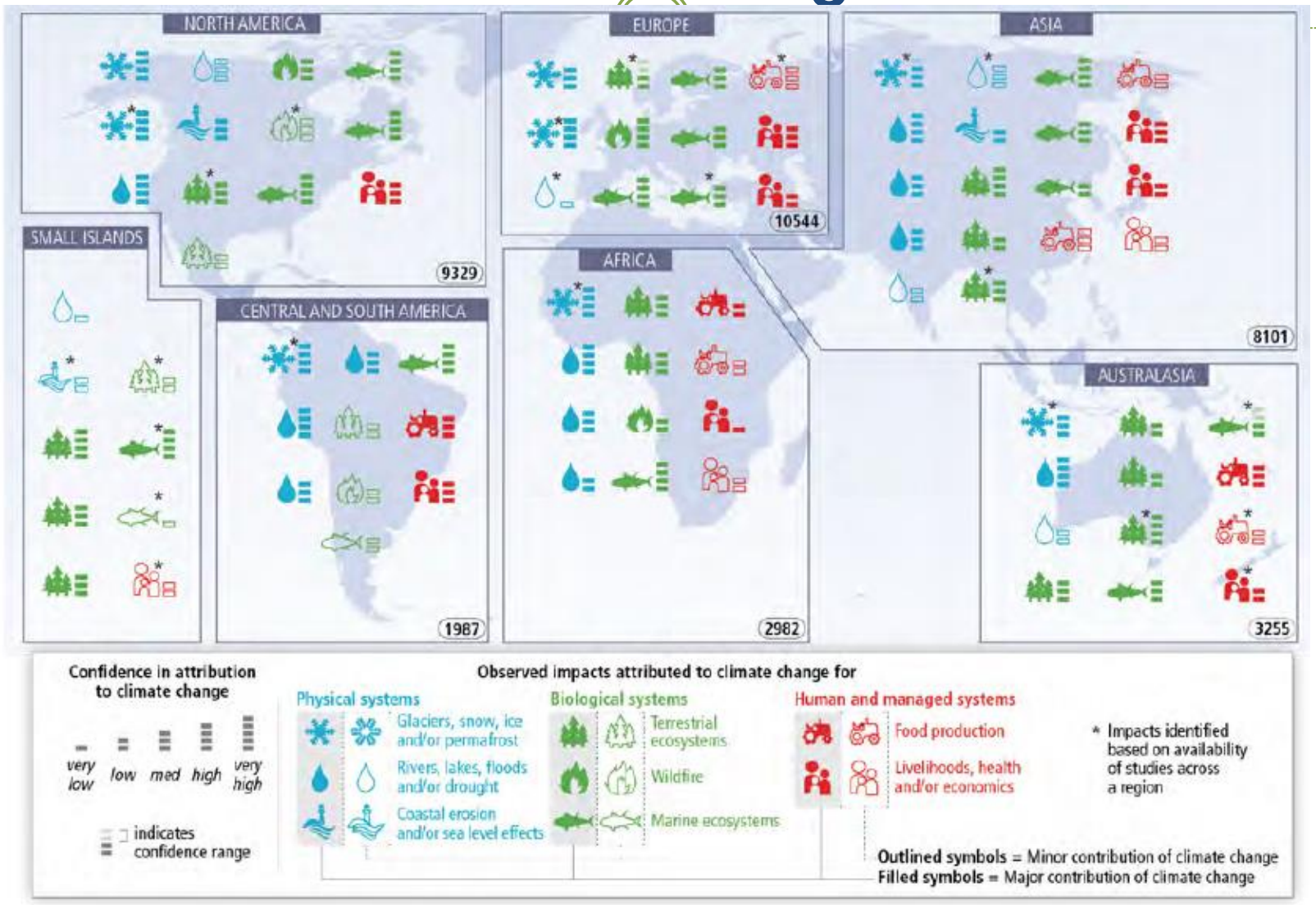


Figure 1.11

Economic Assessment of Climate Change Risk

- Economic losses for temperature increases of ~2.5˚ C above pre-industrial levels are 0.2 – 2% of income.
- Availability of technology can reduce these costs (CCS, nuclear, solar/wind, bioenergy).
- Estimates of the social cost of carbon lie between a few dollars and several hundreds of dollars per tonne of carbon in 2000-2015.
- Many estimates do not account for the possibility of large-scale singular events and irreversible, tipping points.

Constraints and Barriers to Policy

- Longer time-scale and broad human/earth impacts
  - Such as irreversible outcomes
- Mitigating versus paying
  - Cheapest mitigators may not be the ones who should pay
- Carbon leakage
  - Change in relative price, relocation of industry, nested regulation, & weak consumption leakage
- Subsidies to conventional fuels

Effective Adaptation and Mitigation Requires Policies Across Multiple Scales

Alternative Forms of International Cooperation

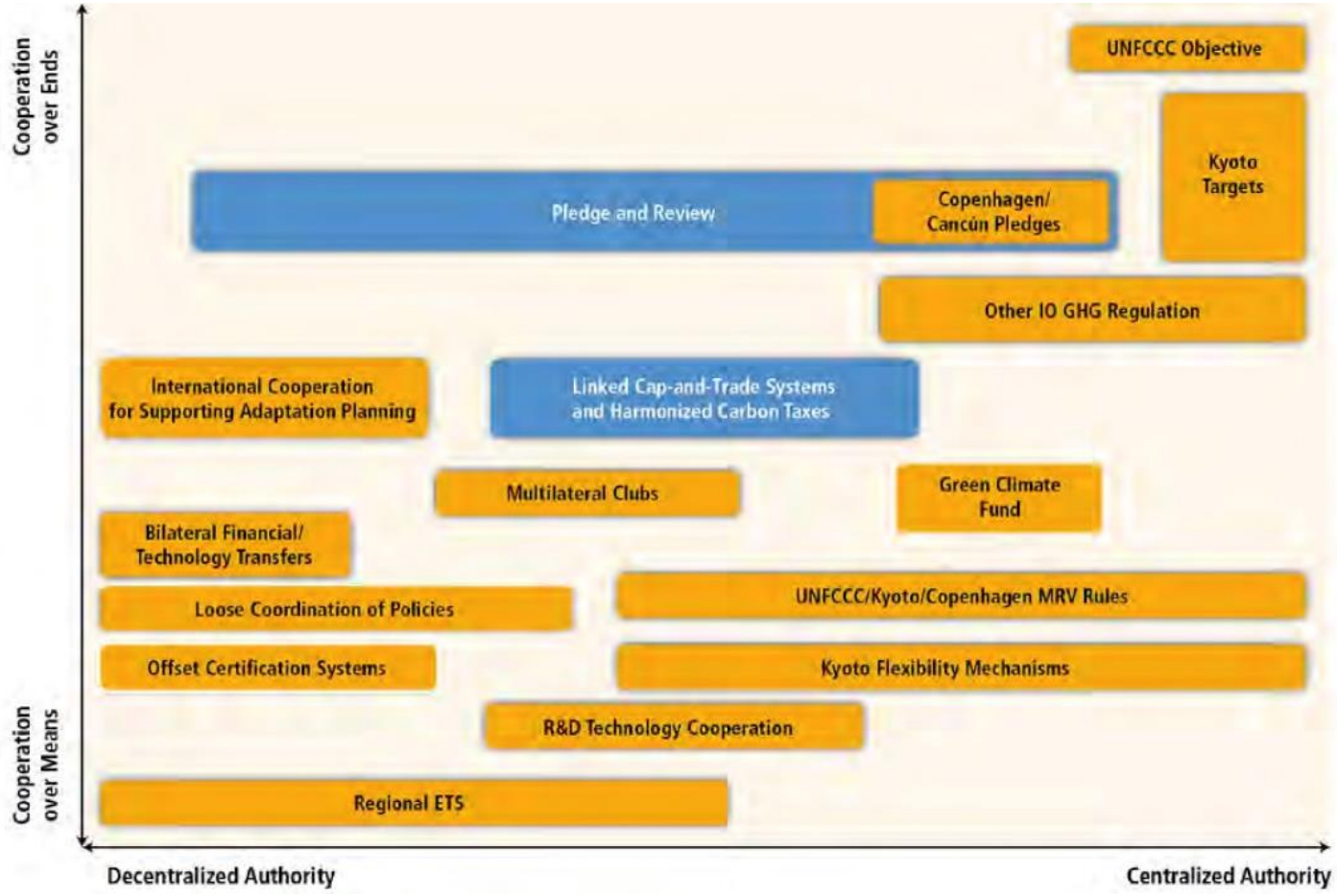
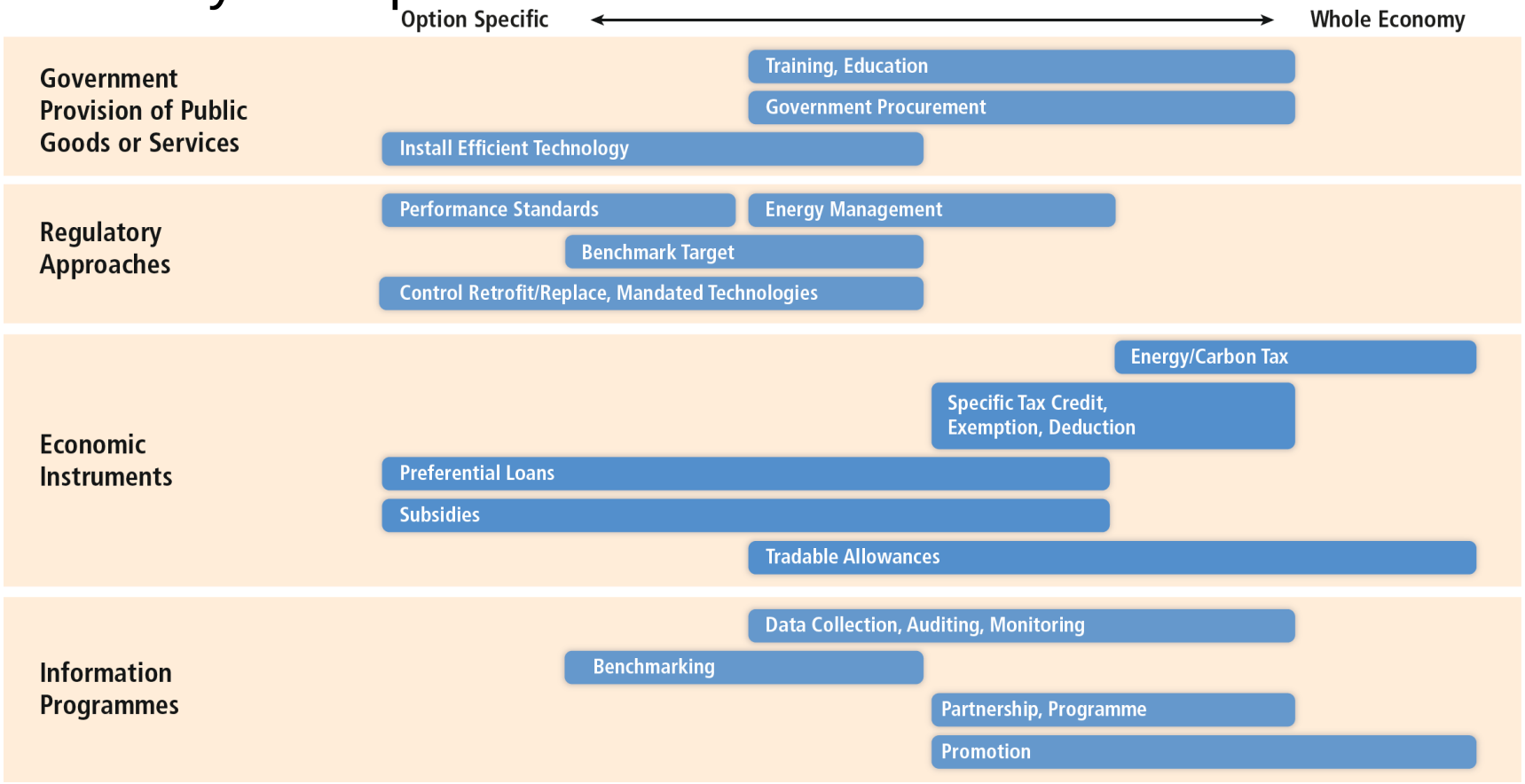


Figure 4.3

Sectoral Policies Dominate

Sector-specific policies have been more widely used than economy-wide policies.



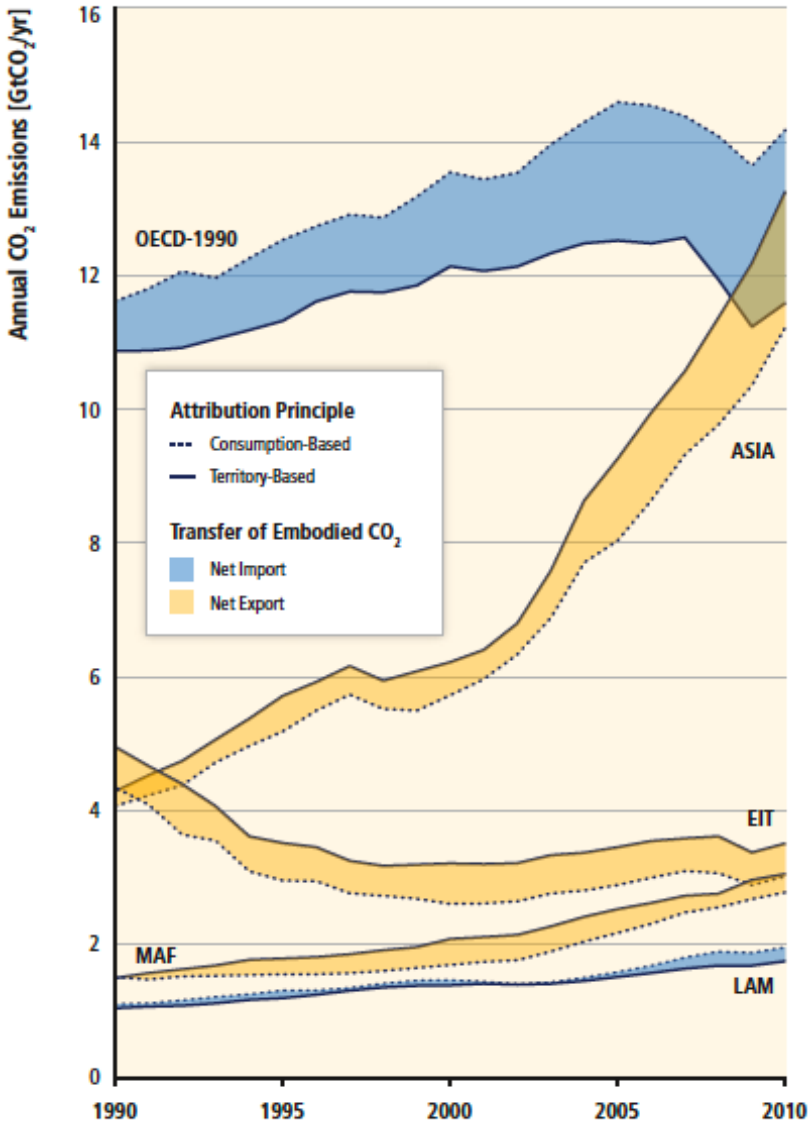
WGIII, Figure 10.15

Metrics: Territorial vs. Consumption Based Emissions

- Territorial based
  - Emissions within territories
    - Done primarily nationally
- Consumption based
  - Territorial emissions minus export emissions plus import emissions
    - High & upper middle income nations show large difference
    - Lower and lower-middle income nations show little difference
    - Emissions regulations in wealthier nations may push emissions to poorer nations

MAF=Middle East & Africa, LAM=Latin America
EIT=Economies in Transition

WGIII, Figure 5.14



Next Steps

- March 25: Observations and future projections of climate change (Kim Cobb, Georgia Tech)
- April 1: Climate change impacts and adaptation: present and future (Ben Preston, ORNL)
- April 8: Transformation pathways: technologies for climate change mitigation (Leon Clarke, PNNL)
- April 22: The challenge ahead: US and global climate policy (Stephen Rose, EPRI)

For More Information

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